

1 **PIPE SEALING TOOL WITH EXTERNAL AND INTERNAL CLAMP**

2 **CROSS REFERENCE TO PRIOR APPLICATIONS**

3 **[0001]** This application claims priority from US Application number 12/715,168, filed on
4 March 1, 2010. The aforementioned related application is incorporated herein by reference
5 in its entirety.

6 **FIELD OF THE INVENTION**

7 **[0002]** The present invention relates to an apparatus for sealing an open end of a pipe
8 using frictional clamping means. In a preferred embodiment, the clamping means includes
9 external and internal clamping components. Once sealed, the pipe can be subjected to
10 pressurization for testing purposes etc.

11 **BACKGROUND OF THE INVENTION**

12 **[0003]** In chemical or petrochemical plants etc., it is often necessary to convey fluidic
13 materials (e.g. liquids) from one location to another. The conveyance of such material
14 normally includes equipment such as conduits or pipes, storage or reaction vessels etc.,
15 which are generally manufactured from metal. The joining of separate pieces of the
16 conveying equipment is generally achieved by welding the necessary pieces together. For
17 example, when joining adjacent ends of pipe together, it is common for each end to be
18 provided with flanges, that are welded to each respective end, which are then bolted
19 together to form a seal. Such flanges may also be provided on holding tanks and other such
20 vessels so that such vessels can be connected to pipes or other vessels. Alternatively, the
21 connections between lengths of pipe or other equipment may be welded directly together
22 (i.e. butt welded) to form the seal. In either case, it will be appreciated that each welded joint
23 or section must form a complete seal so as to prevent leakage of the materials being
24 transported. This is particularly the case when handling potentially hazardous materials
25 such as flammable or toxic liquids.

26 **[0004]** For reasons of safety, it is often necessary to periodically test the integrity of the
27 welds used in joining the various pieces of equipment (such as pipes, vessels, flanges and
28 the like) together.

1 **[0005]** The prior art provides various tools for conducting weld integrity tests on conduits.
2 For example, U.S. Patent numbers 6,131,441 and 5,844,127 (the entire disclosures of which
3 are incorporated herein by reference) teach weld testing tools that isolate a particular section
4 of a pipe (such section including a weld) and subject the section to a high pressure fluid
5 within a constrained annular space defined by the tool and the inner surface of the pipe. The
6 pressure of the fluid within the annular space is monitored whereby any pressure drop
7 signifies a leak in the weld.

8 **[0006]** US Patent number 6,463,791 (the entire disclosure of which is incorporated
9 herein by reference) teaches an apparatus for testing welds used to secure nozzles. As
10 shown in Figure 1 of this reference, the apparatus comprises a first seal plate that is placed
11 on the inner surface of the vessel (for example) and a second seal plate that is secured to
12 the outer, flange portion of the nozzle. In this manner, the nozzle volume is sealed and a
13 pressurizing fluid is introduced therein. Once the volume is filled, the pressure is monitored
14 as above and any leakage detected. Although this apparatus provides an accurate and
15 efficient means of testing welds on nozzles, the size and weight of the apparatus makes it
16 inconvenient for use on large nozzles.

17 **[0007]** Further, applicant's co-pending U.S. application, serial number 11/771,158
18 (publication number US 2008/0121044), provides tools for testing the integrity of welds on
19 pipes and the like. The entire disclosure of such application is incorporated herein by
20 reference.

21 **[0008]** There exists a need for more easily sealing a section of a long pipe for
22 conducting the type of stress tests mentioned above. In addition, there exists a need for an
23 apparatus that is capable of exerting axial stresses on welds during such testing so as to
24 simulate a "worst case scenario". In particular, there is a need for an apparatus that can be
25 easily mounted on an open end of a pipe so as to effectively seal the pipe opening and
26 maintain such seal during high pressurization of the pipe. Such apparatus would not subject
27 the pipe to any damage or otherwise cause weakness thereto.

28 **SUMMARY OF THE INVENTION**

29 **[0009]** In one aspect, the present invention generally provides an apparatus for sealing
30 an open end of a pipe comprising a means for frictionally engaging the interior and exterior
31 surfaces of the pipe.

1 **[0010]** Thus, in one aspect, the invention provides an apparatus for closing and sealing
2 the bore of an open end of a pipe comprising:

3 **[0011]** - a front plate for abutting the end face of the pipe end;

4 **[0012]** - an outer clamping means for frictionally and circumferentially engaging the
5 external surface of the pipe end, said means comprising a segmental outer gripper ring
6 positionable on the external surface and an outer compression ring mountable on the gripper
7 ring, said rings having cooperating contacting ramped surfaces,

8 **[0013]** - means for connecting and urging the front plate and compression ring together
9 so that the compression ring compresses the gripper ring against the pipe end's external
10 surface;

11 **[0014]** -an inner clamping means for frictionally and circumferentially engaging the
12 internal surface of the pipe end, said inner clamping means comprising a segmental inner
13 gripper ring positionable against the internal surface and an inner compression ring mountable
14 within the inner gripper ring, said inner rings having cooperating contacting ramped surfaces;

15 **[0015]** - a movable back plate for transversely positioning within the bore of the pipe end
16 adjacent the inner end of the inner clamping means;

17 **[0016]** - an annular deformable resilient seal means for positioning between the back
18 plate and the inner compression ring;

19 **[0017]** - means for connecting and urging the back plate and inner compression ring
20 together so that they may compress and deform the seal means into sealing engagement with
21 the pipe end's internal surface and so that the inner compression ring may also compress the
22 inner gripper ring against the internal surface;

23 **[0017a]** - means, connecting the black plate with the front plate for urging the back plate
24 toward the front plate when in use; and

25 **[0018]** - whereby the back plate, seal means, inner clamping means and front plate may
26 combine to close and seal the pipe bore when tightened together.

27 **[0019]** In a further embodiment, the invention provides a method for sealing a section of a
28 pipe having an open end, the method comprising:

1 **[0020]** - providing an apparatus having a first clamping means, for frictionally engaging
2 the outer surface of the pipe, and a second clamping means, for frictionally engaging the inner
3 surface of the pipe; and,

4 **[0021]** - forming a seal between the inner surface of the pipe and the second clamping
5 means.

6 **BRIEF DESCRIPTION OF THE DRAWINGS**

7 **[0022]** These and other features of the invention will become more apparent in the
8 following detailed description in which reference is made to the appended drawings wherein:

9 **[0023]** Figure 1 is a cross sectional side view of one embodiment of the inner clamp
10 assembly positioned within a pipe.

11 **[0024]** Figure 2 is a perspective view of part of the clamp assembly of the apparatus of
12 Figure 1.

13 **[0025]** Figure 3 is a cross sectional side elevation of another embodiment of part of the
14 clamp of Figure 1.

15 **[0026]** Figures 4a and 4b are cross sectional side views of further embodiments of the
16 inner clamp assembly positioned within a pipe.

17 **[0026a]** Figure 5 is a cross sectional side view of a front plate and inner clamp assembly
18 associated with a pipe end.

19 **[0026b]** Figure 6 is a cross sectional side view showing an embodiment of inner and
20 outer clamp assemblies associated with a pipe.

21 **[0027]** Figures 7 to 9 are cross sectional views of embodiments having an outer clamp
22 assembly and a front plate positioned at a pipe end.

23 **[0028]** Figure 10 is a perspective view of another embodiment for sealing a pipe end.

24 **[0029]** Figure 11 is a side view of embodiment showing an outer clamp assembly and front
25 plate.

26 **[0030]** Figure 12 is an end view of the outer clamp assembly shown in Figures 10 and 11.

1 **[0031]** Figure 13 is a side cross-sectional view of another embodiment of the outer clamp
2 assembly.

3 **[0032]** Figure 14 is an end view of the embodiment shown in Figure 13.

4 **[0033]** Figure 15 is a side cross-sectional view of another embodiment of an outer clamp
5 assembly and front plate associated with a pipe end.

6 **[0034]** Figures 16 and 17 are front and side cross-sectional views of the compression ring
7 shown in Figure 15.

8 **[0035]** Figures 18 and 19 are front and side cross-sectional views of the clamping ring
9 shown in Figure 15.

10 **[0036]** Figures 20, 21 and 22 are front, side cross-sectional and detailed cross-sectional
11 views of the segmental gripper ring shown in Figure 15.

12 **[0037]** Figure 23 is a side cross-sectional view of the outer clamp assembly and front plate
13 wherein a plurality of clamp assemblies are combined.

14 **[0038]** Figure 24 is a side cross-sectional view of an embodiment of the invention
15 comprising, in combination, a front plate and inner and outer clamp assemblies.

16 **[0039]** Figures 25 and 26 are side cross-sectional and front views of the front plate shown
17 in Figure 24.

18 **[0040]** Figures 27 and 28 are side cross-sectional and front views of the outer
19 compression ring shown in Figure 24.

20 **[0041]** Figures 29 and 30 are front and side cross-sectional views of the inner
21 compression ring shown in Figure 24.

22 **[0042]** Figures 31 and 32 are front and side cross-sectional views of the backplate shown
23 in Figure 24.

24 **[0043]** Figures 33, 34 and 35 are front, side cross-sectional and detailed cross-sectional
25 views of the inner gripper ring shown in Figure 24.

1 **DETAILED DESCRIPTION OF THE INVENTION**

2 **[0044]** Throughout the description of the invention the following terms will be assumed to
3 have the following associated meanings:

4 **[0045]** “Vessel” - will be understood to mean any equipment or apparatus to which a
5 nozzle is attached. As such, the term “vessel” will include vessels per se, pipes, drums, and
6 any other similar equipment. It will be understood that the term “vessel” is used herein simply
7 as a convenient way to encompass all such equipment or apparatus.

8 **[0046]** “Annular” - this term is used to describe a body having at least one outer diameter
9 and at least one inner diameter. Thus, an “annular tube” will be assumed to be a hollow tube
10 with an inner and outer diameter. An “annular disc” will be assumed to be an object having an
11 outer diameter and a central aperture thereby providing an inner diameter.

1 **[0047]** "Axial" - this term will be used to describe a direction taken along the longitudinal
2 axis of a pipe or conduit. Thus, "axial force" or "axial stress" will be understood as being a
3 force applied in a direction parallel to the longitudinal axis of the conduit. Similarly, the term
4 "axially extending" will be understood to mean extending in a direction parallel to the
5 longitudinal axis of the pipe.

6 **[0048]** "Proximal" and "distal" - these terms will be used to describe the positions of
7 various components of the invention once positioned over a pipe having an open end. The
8 term "proximal" will be used to describe a position closer to the open end of the pipe. The
9 term "distal" will be used to describe a position away from the open end of the pipe.

10 **[0048a]** The pairs of terms 'sealing plate' and 'front plate', 'clamp' and 'clamping
11 assembly', 'internal' and 'inner', 'external' and 'outer' are used interchangeably herein.

12 **[0049]** Figure 1 illustrates one aspect of the invention wherein an internal sealing
13 apparatus for a pipe is shown. The sealing apparatus 10 is preferably sized to fit within the
14 lumen of a pipe (or tube) 12. The apparatus 10 comprises a sealing plate 14 having a
15 diameter slightly less than the internal diameter of the pipe 12. The plate includes a first face
16 16 and a second face 18, wherein the second face is adjacent a clamp 20. The second face
17 18 of the sealing plate 14 is provided with beveled edge 22 for accommodating an O-ring 24
18 or other such resilient sealing means.

19 **[0050]** The clamp 20 generally comprises an annular ring having an outer diameter sized
20 to fit within the pipe 12. An annular shape for the clamp 20 is preferred to minimize its weight.
21 However, the clamp 20 may also comprise a solid body. As will be understood by persons
22 skilled in the art having reviewed the present disclosure, the outer diameter of the clamp 20 is
23 preferably slightly less than the internal diameter of the pipe 12 so as to permit axial placement
24 of the clamp 20. The clamp 20 is provided with one or more recesses or pockets 26 into which
25 are placed magnets 28. Preferably, the magnets 28 comprise electromagnets that can be
26 activated when desired.

27 **[0051]** The magnets 28 provided on the clamp 20 are designed to magnetically attract the
28 wall of the pipe 12, which, as is commonly known in the art, is formed from a ferrous metal.
29 The magnets 28 are designed to form a strong clamping force with the interior wall of the pipe
30 12 and, thereby, to anchor the clamp in a fixed axial position within the pipe 12. In a preferred
31 embodiment, at least two or more magnets 28 are provided on the clamp 20 with such
32 magnets being placed circumferentially around the annular clamp 20. Such an arrangement
33 will serve to evenly secure the clamp 20 within the pipe 12. Although the

1 present description refers to a number of magnets being provided on the clamp, in other
2 embodiments, one or more shaped magnets can be provided so as to achieve the desired
3 clamping force.

4 **[0052]** The clamp 20 is releasably secured to the sealing plate 14. In one embodiment,
5 the clamp is provided with one or more, and preferably a plurality, of bolts 30 adapted to be
6 inserted into holes 31 provided on the sealing plate. Nuts 32 cooperate with the bolts 30 to
7 secure the sealing plate 14 to the clamp 20. It will be understood that a sealing means (not
8 shown) may be provided between the bolts 30 and the nuts 32 and/or holes 31 in the sealing
9 plate 14 to provide a seal and, thereby, prevent leaks through the holes 31.

10 **[0053]** Figure 2 illustrates an embodiment of the clamp 20 illustrating the circumferential
11 placement of the magnets 28 and the bolts 30. As mentioned above, although the clamp 20
12 is shown in Figure 2 in the form of an annulus, it may also comprise a solid body. In either
13 embodiment case, in order to reduce the weight of the clamp 20, it may be formed of a light
14 material such as aluminum. The sealing plate 14 may also be formed of aluminum.
15 However, it will be understood that the choice of material for the clamp 20 and/or the sealing
16 plate 14 may be chosen from a variety of others.

17 **[0054]** As can be seen in Figure 1, upon tightening of the nuts 32, the sealing plate 14 is
18 forced against the opposing face of the clamp 20. In the course of this process, the resilient
19 seal 24 (i.e. the O-ring) is elastically deformed. The bevel 22 provided on the sealing plate
20 14 causes such deformation to expand radially outwardly.

21 **[0055]** In use, the apparatus 10 is first inserted within a pipe 12. The apparatus 10 is
22 axially positioned in a desired location within the pipe 12. It will be understood that the
23 apparatus may be preassembled prior to the positioning step. That is, the sealing plate 14
24 may be loosely connected to the clamp 20. Alternatively, the sealing plate 14 and clamp 20
25 may be inserted separately within the pipe 12. Once the apparatus 10 is positioned at the
26 desired location, the sealing plate 14 is connected to the clamp 20 (if not already) by first
27 inserting the bolts 30 through the holes 31 and attaching the cooperating nuts 32 thereto. As
28 mentioned above, any type of seal (such as washers, packing etc.) may also be provided so
29 as to seal the holes 31. Tightening of the nuts 32 forces the sealing plate 14 against the
30 clamp 20 and, as discussed above, results in the outward radial deformation of the seal 24.
31 The seal 24 is thereby forced against the inner wall of the pipe 12 resulting in a pressure
32 resistant seal there-between.

1 **[0056]** Either before the tightening of the nuts 32 or after, the magnets 28 provided on
2 the clamp 20 are activated resulting in a strong attraction force being formed between the
3 magnets 28 and the wall of the pipe 12. It will be understood that the magnets used in the
4 invention are chosen so as to provide the required clamping force to prevent axial movement
5 of the clamp 20 within the pipe 12. As mentioned above, the magnets 28 preferably
6 comprise electro magnets. In such case, one or more power supply units (not shown) will be
7 connected to the magnets 28 in order to activate same.

8 **[0057]** Once the clamp 20 is secured to the pipe 12 and the sealing plate 14 is secured
9 and sealed against the clamp 20, the lumen of the pipe 12 facing the first face 16 of the
10 sealing plate may then be pressurized with a gas or liquid without leakage beyond the
11 sealing plate 14.

12 **[0058]** Figure 3 illustrates another embodiment of the clamp 20 having an annular
13 structure wherein an inwardly extending flange 34 is provided to accommodate the bolts 30.
14 The bolts may be permanently attached to the flange 34 (or the face of the clamp 20) by
15 means of welds etc., may be integrally formed therewith, or may extend there-through and
16 be secured with nuts (not shown).

17 **[0059]** Figure 4 illustrates the use of the sealing apparatus of the invention for the dual
18 purposes of sealing and testing a pipe. As shown, a pair of apparatuses 10a and 10b is
19 provided within a pipe 12 and positioned on opposite sides of a weld 36, the integrity of
20 which is to be tested. Apparatus 10a is essentially identical to that shown in Figure 1 and as
21 described above. As discussed above, apparatus 10a includes a sealing plate 14a joined to
22 a clamps 20a by means of nuts and bolts 32a and 30a, respectively. Clamp 20a includes at
23 least one magnet 28a, and preferably two or more magnets generally circumferentially
24 equidistantly spaced. A seal is formed between the apparatus 10a and the inner wall of the
25 pipe 12 by means of a resilient seal 24a, which may comprise an O-ring. The magnets 28a
26 are activated to secure the clamp to the pipe 12 at the desired location. As explained above,
27 such securing results when the attraction force of the magnets creates a tight friction
28 engagement between the magnet and the pipe 12 surface.

29 **[0060]** Apparatus 10b of Figure 4 is similar to the apparatus 10a described above and
30 similar elements are identified with similar reference numerals but with the letter "b" added
31 for clarity. As shown, apparatus 10b is positioned within the pipe 12 on the opposite side of
32 the weld 36 from apparatus 10a. In this manner, the two apparatuses 10a and 10b combine
33 to seal off a section of the pipe 12 thereby forming a sealed space 37. In the case of

1 apparatus 10b, the sealing plate 14b is provided with at least one fluid port 38 through which
2 the sealed space 37 can be filled with a pressurizing fluid (i.e. a liquid or a gas). In a
3 preferred embodiment, as illustrated in Figure 4, two ports 38 are provided so that one is
4 used to fill the space 37, for example with water, while the other is used to vent any air there-
5 within. It will be appreciated that any number of ports 38 can be provided. One or more of
6 the ports 38 is preferably connected to a pressure gauge or other similar device (not shown)
7 to monitor the pressure created within the space 37. As will be known to persons skilled in
8 the art, a test of the weld 36 involves applying a constant high pressure to the interior of the
9 pipe and monitoring such pressure over a period of time. Any drop in pressure signifies a
10 leak in the weld.

11 **[0061]** In use, the system illustrated in Figure 4 first involves placing and securing the
12 apparatuses 10a and 10b in the manner described above. The sealed space 37 is then filled
13 with a pressurizing fluid and, as described above, the pressure is monitored.

14 **[0062]** Apart from the testing function provided by the system shown in Figure 4, a
15 further feature of the invention will also be understood. Specifically, by creating a sealed
16 pressurized space 37 between the apparatuses 10a and 10b, it will be seen that the
17 pressure applied to the weld 36 also provided a separating force between the two
18 apparatuses. However, since the apparatuses are secured, or clamped, to the interior of the
19 pipe, such separating force also serves to apply an axial force against the weld 36. In this
20 way, the system shown in Figure 4 applies both radial and axial forces against the weld 36
21 thereby more accurately simulating a "worst case" scenario for conducting the weld test. It
22 will be understood that such simulated stresses will provide more accurate results for the
23 test.

24 **[0063]** Figure 4b illustrates a variation of the assembly shown in Figure 4. In the case of
25 Figure 4b, the apparatus 10a and 10b are essentially the same as that discussed above in
26 that each includes at least one clamp 20a and 20b, respectively, which are provided within a
27 pipe 12. Clamps 20a and 20b include magnets 28a and 28b arranged in the same manner
28 as described above. The main difference between the assembly shown in Figure 4 and 4b
29 lies in the sealing plates 14a and 14b. In the case of Figure 4b, the sealing plates 14a and
30 14b are general of an annular disc shape, wherein each includes a generally central
31 opening. As will be appreciated by persons skilled in the art, this allows the plates 14a and
32 14b to be of much reduced weight thereby facilitating use of the assembly in large diameter
33 pipes.

1 **[0064]** In addition, the sealing plates 14a and 14b of Figure 4b are joined together by a
2 tube 15 extending between each plate. The tube 15 includes an inner diameter that is
3 preferably larger than the diameters of the openings provided in plates 14a and 14b.
4 Further, the outer diameter of the tube 15 is less than the inner diameter of the pipe 12.
5 When the assembly of apparatuses 10a and 10b is installed within a pipe 12, a sealed
6 annular space 35 is thus formed between the two seals 24a and 24b, the outer surface of
7 the tube 15 and the inner surface of the pipe 12. The tube 15 is also preferably provided
8 with one or more ports as discussed above. In Figure 4b, two ports, 38 and 38' are shown.
9 The ports are used to fill and/or vent the annular space 35 in the same manner as described
10 above. As can be seen, the volume of the space 35 is minimized due to the presence of the
11 tube 15 and, therefore, the volume of fluid required to fill the space is minimized.

12 **[0065]** Figure 5 illustrates the use of a sealing apparatus of the invention in a manner
13 similar to that shown in Figure 4. In the example illustrated in Figure 5, a weld 40 is used to
14 secure a flange 42 to the end of a pipe 12. It will be understood that pipe 12 may be a pipe
15 used for conveying as described above or may be the conduit portion of a nozzle provided
16 on a vessel and the like. In this example, an apparatus 10c essentially the same as that
17 shown in Figure 1 is used to seal the pipe 12 on one side of a weld 40 opposite to the flange
18 42. In Figure 5, the elements of apparatus 10c that are similar to the apparatus of Figure 1
19 are shown with the same reference numerals but with the letter "c" added for clarity. The
20 method of positioning and sealing the apparatus 10c is the same as described above. In this
21 example, the open end of the flange 42 is sealed with a plate 44. The plate 44 is formed
22 with a series of circumferentially spaced bolt holes that correspond with bolt holes that are
23 normally present on the face of the flange 42. Once the bolt holes of the plate 44 are
24 aligned with those of the flange 42, bolts 45 are inserted there-through and secured with
25 nuts 46. As shown in Figure 5, nuts may be provided on both ends of the bolts 45. It will be
26 understood that the bolts 45 may have one end with an integral or welded bolt head thereby
27 avoiding the need for nuts on both ends thereof. It will be understood that any needed seal
28 such as a gasket and the like (not shown) may be provided at the junction of the faces of the
29 flange 42 and plate 44.

30 **[0066]** The plate 44 is provided with at least one port 38c in a manner similar to that
31 described above with reference to Figure 4. The ports 38c serve to fill the sealed space 37c
32 between the flange 42 and the sealing apparatus 10c. As shown in Figure 5, the sealed
33 space 37c includes the weld 40 that secures the flange 42 to the end of the pipe 12.

1 **[0067]** In using the system shown in Figure 5, the sealing apparatus 10c is first installed
2 within the pipe 12 in the manner described above. The plate 44 is then installed at the outer
3 face of the flange 42. The plate 44 is secured to the flange 42 so as to form a pressure tight
4 seal there-between. As mentioned above, any needed gaskets etc. can be used for this
5 purpose. Once the plate 44 and the apparatus 10c are secured and clamped, a pressurized
6 fluid is injected through one or more of the ports 38c so as to pressurize the space 37c. As
7 discussed above with respect to Figure 4, the apparatus shown in Figure 5 also serves to
8 apply both a radial as well as axial stress on the weld 40.

9 **[0068]** Figure 6 illustrates a further embodiment of the invention wherein the apparatus
10 10 of Figure 1 is provided within a pipe 12. However, in this example, the exterior surface of
11 the pipe is provided with a retaining collar 48 comprising a generally annular body having an
12 inner and outer diameter. The inner diameter of the collar 48 is provided with a number of
13 circumferentially spaced magnets 50 designed to abut the outer surface of the pipe 12. The
14 magnets 50 of the collar 48 are arranged so as to overlap magnets 28 provided on the clamp
15 20 when the collar 48 is positioned in the same axial position as the clamp 20. The magnets
16 50 of the collar 48 may be provided with a different power source or the same as that
17 powering magnets 28 of the clamp 20.

18 **[0069]** With the embodiment of Figure 6, it will be understood that the combination of the
19 magnetic attraction forces of both sets of magnets 28 and 50 will serve to provide an
20 enhanced clamping force for the apparatus. In other words, the collar 48 serves to reinforce
21 the clamp 20. In a further embodiment, the polarity of the magnets 28 and 50 can be
22 adjusted so as to form a magnetic attraction force there-between. In this manner, the
23 combination of the clamp 20 and collar 50 can be used with non-ferrous pipes as well such
24 as pipes made from aluminum or stainless steel etc. In such case, it will be understood that
25 the magnets 28 and 50 will be provided with a pipe contact surface having a sufficient
26 coefficient of friction to prevent the apparatus from sliding over the pipe 12. Similarly, even
27 in the case of ferrous pipes, such a friction surface may be provided on the magnets 28
28 and/or 50.

29 **[0070]** It will be understood that the collar 48 may be used with any of the clamps
30 discussed above.

31 **[0071]** Figure 7 illustrates a further embodiment of the invention for sealing an end of a
32 pipe. As shown a pipe 12 having an open end 52 is provided with an end plate 54 adapted
33 to close the open end. The end plate 54 is preferably provided with a circular race 56 for

1 receiving therein the end 52 of the pipe 12. As will be understood, the width of the race 56
2 will generally be sized to accommodate the thickness of the pipe 12. The race 56 is also
3 preferably provided with a resilient sealing member 58 so as to form a seal between the
4 plate 54 and the end 52 of the pipe 12.

5 **[0072]** The plate 54 is provided with diameter greater than that of the pipe 12 so as to
6 form a radially extending anchoring flange 60. In another embodiment, the plate 54 may
7 have a diameter closer to that of the pipe 12 but be provided with radially extending arms to
8 form an equivalent to the anchoring flange 60.

9 **[0073]** The anchoring flange 60 is provided with a plurality of circumferentially spaced
10 bolt holes 62 through which are passed bolts 64. On the face of plate 54 opposite the pipe
11 end 52, the bolts 64 are secured with nuts 66. The opposite ends of the bolts 64 are
12 secured to a clamping collar 68 comprising a generally annular body circumferentially
13 extending around the external surface of the pipe 12. The clamping collar 68 includes a
14 radially outwardly extending flange 70 facing the plate 54. The flange 70 is provided with a
15 plurality of bolt holes 72 corresponding to the bolt holes 62 on the plate 54 and adapted to
16 receive the opposite ends of the bolts 64. The flange 70 is secured to the bolts 64 with nuts
17 74. In another embodiment, it will be understood that the bolts 64 can be welded or formed
18 with either the plate 54 or the flange 70 thereby requiring only one set of nuts 66 or 74.

19 **[0074]** The clamping collar 68 is provided with one or more magnets 76 circumferentially
20 around the inner diameter thereof and directed towards the outer surface of the pipe 12.
21 The magnets 76 are provided within recesses or pockets 77 provided in the body of the
22 collar 68. As discussed above, the magnets 76 may preferably comprise electro magnets
23 coupled to one or more power sources (not shown). In a preferred embodiment, a plurality
24 of magnets 76 are provided generally equidistantly around the circumference of the pipe 12
25 so as to evenly distribute the associated clamping forces.

26 **[0075]** In another embodiment, the clamping collar 68 may be provided in one or more
27 sections.

28 **[0076]** In operation, the clamping collar 68 is mounted on the outer surface of the pipe
29 12. At this time, the magnets 76 may be activated so as to form a magnetic attraction force
30 between the magnets and ferrous pipe 12. The strength of the magnets will be chosen so as
31 to form an adequate clamping force between the collar 68 and the pipe 12 so as to prevent
32 relative axial movement there-between. As mentioned above, the magnets 76 may be

1 provided with a friction enhancing surface to assist in preventing relative axial movement
2 between the collar 68 and the pipe 12.

3 **[0077]** Once the clamping collar 68 is secured to the pipe 12 surface, the plate 54 is
4 then mounted against the open end 52. The plate is mounted so that the end of the pipe 12
5 is received within the race 56. At this time, the bolts 64 are positioned and secured with
6 bolts 66 and 74. As will be understood, tightening of the bolts results in the plate being
7 forced against the open end 52 of the pipe 12 and, thereby, the end of the pipe being sealed.

8 **[0078]** Once the end of the pipe 12 is sealed with the plate 54, the interior of the pipe
9 can then be pressurized to test, for example, any welds provided on the pipe.

10 **[0079]** In a further embodiment, as shown in Figure 8, the plate illustrated in Figure 7
11 can be provided with ports 39, which are similar to those shown as element numbers 38c in
12 Figure 5. As will be understood, the apparatus shown in Figure 8 can be used to pressurize
13 the interior of the pipe 12 so as to apply a radial and axial stress therein. In this manner, a
14 weld on the pipe, downstream of the end 52 may be tested with the apparatus of Figure 8
15 without the need to localize the testing apparatus at the region of the weld. It will also be
16 understood that the apparatus of Figure 8 can be used in combination with, for example, the
17 sealing apparatus 10 or 10c of Figures 1 or 5 so as to isolate a segment of a pipe for testing
18 purposes.

19 **[0080]** A further embodiment of the apparatus of Figures 7 and 8 is illustrated in Figure 9
20 wherein like elements are indicated with like reference numerals. Elements that are similar
21 but not identical are indicated with like reference numerals but with the letter "d" added for
22 clarity. As can be seen, in the embodiment of Figure 9, the clamping collar 68d does not
23 include any magnets for engaging the wall of the pipe 12. In the example of Figure 9, the
24 clamping collar 68d is provided in two or more sections that are joined together by means of
25 cooperating radially extending flanges 78. Each of the flanges 78 are provided with bolt
26 holes 80 through which bolts (not shown) are passed. Nuts (not shown) cooperate with the
27 bolts to join opposing flanges 78 together thereby securing the flanges together. The
28 clamping collar 68d of Figure 9 is sized so that tightening of the flanges 78 to each other
29 forms a strong frictional engagement with the outer surface of the pipe 12.

30 **[0081]** As discussed above with respect to other aspects of the invention, once the
31 clamping collar, or clamp 68d is secured to the outer surface of the pipe, a sealing plate 54
32 may be secured to open end of the pipe 12. In the same manner as described above, the

1 sealing plate 54 is secured to the clamp 68d by means of an urging means. In the
2 embodiment shown, such urging means is provided by a combination of nuts and bolts that
3 join the clamp 68d to the sealing plate. Tightening of such nuts urges the sealing plate 54
4 towards the clamp 68d. In view of the frictional engagement of the clamp 68d to the outer
5 surface of the pipe 12, it is prevented from movement with respect to the pipe 12. In
6 particular, relative axial movement of the clamp 68d and the pipe 12 is prevented. In the
7 result, the sealing plate 54 is pressed against the open end of the pipe 12 and, thereby seals
8 such open end in the same manner as described above.

9 **[0082]** Figure 10 illustrates a further aspect of the invention wherein a clamp is provided
10 on the outer surface of a pipe, adjacent an open end of thereof, and a sealing plate (or other
11 similar means) is provided to seal the open end of the pipe. In the embodiment shown in
12 Figure 10, the clamp 90 is similar in design to that shown in Figure 9. However, as
13 illustrated, the clamp 90 is formed of a plurality of sections 92a, 92b, 92c etc., which are
14 adapted to be joined together to form a circumferential collar (i.e. the clamp 90) around the
15 surface of a pipe 12. In Figure 10, only sections 92a, 92b, 92c are shown. However, it will
16 be understood that the clamp 90 shown in Figure 10 includes other sections that extend on
17 the opposite side of the pipe shown therein. It will also be understood that the number of
18 sections forming the clamp 90 will depend on the size (i.e. length) of each section and the
19 outer diameter of the pipe. For example, for small diameter pipes, only two sections may be
20 needed (as shown in Figure 9). However, for larger diameter pipes such as that shown in
21 Figure 10, the clamp 90 may be provided in several sections.

22 **[0083]** The sections forming the clamp 90 are provided with a pair of radially extending,
23 longitudinal "connecting" flanges, one at each end of the clamp section. The term "radially
24 extending, longitudinal" refers to the orientation of the flanges when the clamp 90 is in use
25 on a pipe. The term "connecting" refers to the use of such flanges in connecting adjacent
26 clamp sections together. As shown and described further below, the connecting flanges
27 extend radially outwardly away from the pipe 12. Further, these flanges extend in a direction
28 parallel with the longitudinal axis of the pipe 12. As shown in Figure 10, clamp section 92b is
29 shown with flanges 94b and 95b at the opposite ends thereof. Each of the connecting
30 flanges extend in the same direction, perpendicularly to the body of the respective section.
31 When the clamp 90 is assembled, as shown in Figure 10, the flanges extend radially
32 outwardly, away from the pipe, and extend in a direction generally parallel to the longitudinal
33 axis of the pipe 12. As shown, when the clamp 90 is in the assembled state over a pipe 12,
34 the flanges of each adjacent section of the clamp 90 abut each other. For example, as

1 shown in Figure 10, the flange 94b of section 92b is positioned in facing arrangement
2 against flange 95a of section 92a. Similarly flange 95b is positioned in facing arrangement
3 against flange 94c of section 92c. Flanges of other sections of the clamp 90 would be
4 similarly arranged in a facing, or opposing manner. The opposing flanges of adjacent clamp
5 sections are joined together using a number of bolts 96 (or "clamping bolts") that extend
6 through bolt holes provided in the flanges. The flanges are then secured together by nuts 98
7 that cooperate with the bolts 96. In this manner, the opposing flanges of each clamp section
8 are secured together, thereby forming the clamp 90. As the flanges of the clamp sections
9 are urged together, the internal diameter of the clamp 90 is gradually reduced. Thus, by
10 appropriately sizing the clamp 90 with respect to the outer diameter of the pipe 12, the clamp
11 90 can be secured to the pipe 12 outer surface, whereby relative movement between the
12 pipe 12 and the clamp 90 is prevented. It will be understood that in order for such tight fit to
13 occur, there should be provided some clearance between the clamp sections to allow a
14 reduction in the inner diameter of the clamp 90 once positioned over a pipe 12. It will also
15 be understood that by providing bolts 96 of sufficient length, one clamp 90 may be used for a
16 range of outer diameters of pipes.

17 **[0084]** The sections forming the clamp 90 are also each provided with a radially
18 extending, circumferential "sealing" flange section 100, extending along the length of each
19 section and extending between the opposing connecting flanges. The term "radially
20 extending, circumferential" refers to the orientation of the sealing flange, wherein, when the
21 clamp 90 is assembled and in use, each flange section extends radially away from the pipe
22 and perpendicular to the longitudinal axis of the pipe 12. The term "sealing" refers to the use
23 of such flange section in securing a sealing plate (described below) against the open end of
24 the pipe 12. As shown in Figure 10, clamp sections 92a, 92b and 92c are provided,
25 respectively, with sealing flange sections 100a, 100b and 100c. For convenience, the
26 circumferential sealing flange formed by the respective sections will be identified with
27 element number 100. In the assembled state of the clamp 90, the sealing flanges sections
28 of the clamp sections combine to form a radially extending sealing flange 100 on the clamp,
29 wherein such flange extends radially outwardly away from the pipe 12 and transverse to the
30 longitudinal axis of the pipe 12. In this manner, when the clamp 90 is assembled on a pipe,
31 the sealing flange sections of each clamp section align over the circumference of the pipe 12
32 to form a generally unitary flange 100. The sealing flange sections of the clamp sections are
33 also provided with a number of bolt holes 102, which are discussed further below.

1 **[0085]** In order to seal the open end of the pipe 12, a sealing plate 104 is provided. The
2 sealing plate 104 is preferably sized to have a diameter that is greater than the diameter of
3 the pipe 12. Along the outer edge of the sealing plate are provided a number of bolt holes
4 106 that are positioned to cooperate with the bolt holes 102 provided in the sealing flange
5 100. As discussed above with respect to other embodiments, in use, once the clamp 90 has
6 been secured to the outer surface of the pipe 12, the sealing plate 104 is then secured to the
7 clamp 90. In this process, the sealing plate is positioned against the opening of the pipe 12
8 and a plurality of bolts (not shown) are passed through aligned bolt holes, 102 and 106, of
9 the sealing plate 104 and the sealing flange 100. Such bolts may be referred to herein as
10 "sealing bolts". As discussed above, the sealing plate 104 is preferably provided with a
11 sealing means for sealingly engaging the open end of the pipe 12. In one aspect, the
12 sealing plate may be provided with a groove or race (not shown in Figure 10 but shown by
13 example in Figures 7-9) and an appropriate sealing member for engaging and sealing the
14 open end of the pipe. In operation, the sealing plate 104 is brought against the open end of
15 the pipe 12 by, for example, causing the end of the pipe to be received in the groove
16 provided on the sealing plate 104. The bolt holes 106 of the sealing plate 104 are then
17 aligned with bolt holes 102 of the sealing flange 100. The sealing bolts (not shown) are then
18 passed through the aligned bolt holes 102 and 106 and secured with nuts (not shown). As
19 described above, tightening of the nuts results in the sealing plate 104 being urged towards
20 the clamp 90 and, due to the immobilization of the clamp 90 on the pipe 12, the sealing plate
21 104 is thereby urged against the end of the pipe 12. The nuts are tightened until a sufficient
22 seal is provided for the open of the pipe 12. Once in this state, the interior of the pipe may
23 then be pressurized for conducting a test or any other purpose. The sealing plate 104 may
24 be provided with one or more ports 108 to which may be connected pressurizing means,
25 pressure gauges or any other instrument or apparatus.

26 **[0086]** As also shown in Figure 10, in some instances, a reinforcement apparatus 110
27 may be used within the interior of the pipe so as to brace against the compressive forces of
28 the clamp 90. In one example, the reinforcement apparatus 110 comprises a plurality of
29 radially extending arms 112 connected together at a central hub 114. The hub 114 would
30 generally be positioned on the longitudinal axis of the pipe 12. The ends of the arms 112
31 opposite the hub 114 preferably terminate in a pad 116 adapted to bear against the inner
32 surface of the pipe 12. Each of the arms are provided with tensioning means 118 that serve
33 to lengthen the arms so as to force the pads 116 against the wall of the pipe 12. In one
34 aspect, the tensioning means 118 are formed by a combination of the arms 112 having a

1 threaded portion and lengthening nuts associated with such threaded portions. Such means
2 of lengthening a rod are known in the art. Similarly, any other means of lengthening the
3 arms 112 may be used and the invention is not limited to any particular means for achieving
4 such purpose. In certain cases, such as for example with large diameter pipes, the arms
5 112 of the reinforcement apparatus 110 may be provided with a support ring 120 to prevent
6 or reduce movement of the arms 112 outside of the plane of the reinforcement apparatus
7 110. It will be understood that any number of arms 112 may be provided on the
8 reinforcement apparatus 110.

9 **[0087]** As will be understood, in use, the reinforcement apparatus 110 would be
10 positioned inside of the pipe 12 prior to placement of the sealing plate 104. Moreover, the
11 reinforcement apparatus 110 would be positioned prior to establishing the clamping force of
12 the clamp 90 on the pipe 12. In this way, as the clamp 90 is tightened over the outer wall of
13 the pipe 12, the reinforcement apparatus 110 serves to prevent any inward deflection or
14 deformation of the pipe 12.

15 **[0088]** In some cases, the inner surface of the clamp 90 (or 68d) may be provided with a
16 gripping means such as teeth or ribs etc. However, in a preferred embodiment, the inner
17 surface of the clamp (90, 68d etc.) is smooth as to prevent damage to the surface of the pipe
18 12.

19 **[0089]** Figure 11 illustrates another embodiment of the invention described in Figure 10.
20 In Figure 11, the clamp 90 is shown as above, provided over a pipe 12 and proximal to an
21 open end of the pipe to be sealed. However, as shown, a further circumferential clamp 122
22 is provided adjacent to the clamp 90. The clamp 122 is of the same general construction as
23 clamp 90 described above. As illustrated, clamp 122 is positioned on the side of the clamp
24 90 opposite the opening of the pipe 12. As will be understood, the additional clamp 122
25 provides added clamping force. In order to establish a physical connection between the
26 clamps, clamp 90 is provided with an additional radially extending circumferential flange 124
27 on a side opposite to the flange 100 described above. Clamp 122 includes at least one
28 radially extending circumferential flange 126, on the side adjacent to the clamp 90. The
29 flanges 124 and 126 are provided with a plurality of bolt holes that are aligned during
30 installation so as to allow bolts 128 to extend there-through. Nuts 130 cooperate with the
31 bolts 128 to securely connect the clamps 122 and 90 together. Preferably, bolt holes 128
32 are evenly spaced along the circumference of the flanges 124 and 126. As will be
33 understood, connection of the clamps 122 and 90 serves to provide additional clamping

1 force since the clamping surface area is increased. In the above description, the clamps
2 122 and 90 and the respective flanges 124 and 126 have been described as singular
3 elements. However, as described above, each is comprised of two or more clamp sections
4 that are connected together to form such elements. As shown in Figure 11, the clamp 122
5 may be provided with a further radially extending circumferential flange 125 to which another
6 clamp may be connected if necessary. It will be understood that any number of clamps can
7 be combined in order to provide any desired level of clamping force.

8 **[0090]** As also shown in Figure 11, the sealing plate 130 comprises a bell-shaped
9 element. The sealing plate 130 functions in the same manner as the sealing plate 104
10 described previously. However, the curved, or outwardly convex structure of the plate 130
11 allows, for example, a number of ports 132, 133, 134 to be provided over the surface
12 thereof. The sealing plate 130 is secured to the clamp 90 using bolts 136 and associate
13 nuts as described previously.

14 **[0091]** Figure 12 provides an isolated view of a clamp such as clamp 90 or 122 shown in
15 Figures 10 and 11. As seen, the clamp of Figure 12 is comprised of six essentially identical
16 sections 92. For convenience, when referring to the clamp sections collectively (or portions
17 of such clamp sections), the element number 92 is used without the letter suffixes. Each
18 section includes a curved inner surface 97 adapted to conform to the outer surface of a pipe
19 (not shown) to which the clamp is to be secured. As described above, each section includes
20 opposing radially extending, longitudinal connecting flanges 94 and 95, which, when the
21 clamp is assembled, are placed in opposing arrangement as shown in Figure 12. Bolts 96
22 and associated nuts 98 serve to connect each section 92 together so as to form the clamp
23 90 for circumferentially fitting over the surface of a pipe. As described above, a space is
24 preferably provided between at least some of the adjacent clamp sections 92 so as to allow
25 sufficient clearance for the sections to be tightened towards each other, and thereby,
26 tightened over the outer surface of the pipe. Such tightening serves to provide the
27 necessary clamping force over the circumference of the pipe. Each of the sections 92
28 further includes a radially extending, circumferential sealing flange section 100 that is
29 adapted to engage the sealing plate when the clamp is in use (as discussed above).

30 **[0092]** Figures 13 and 14 illustrate another embodiment of the invention. As shown the
31 embodiment of Figures 13 and 14 functions in effectively the same manner as above. That
32 is, in general, a pipe 12 is provided with a circumferential clamp 150 proximal to an open end
33 of the pipe. The clamp 150 is tightened over the outer surface of the pipe 12 so as to secure

1 same and to prevent relative movement between the clamp and the pipe 12. As shown in
2 Figure 13, a sealing plate 152 is provided against the open end of the pipe 12 and
3 subsequently secured to the clamp 150.

4 **[0093]** As shown in Figure 13, the clamp 150 of this embodiment is operable differently
5 from that of the previous figures. Specifically, the clamp 150 is comprised of two or more
6 clamp sections. In the embodiment shown in Figures 13 and 14, the clamp 150 is comprised
7 of two sections, 154 and 155. As described above, the clamp may be formed using any
8 number of sections, depending upon, inter alia, the size of each section and the outer
9 diameter of the pipe in question. In the case where the clamp 150 is formed in two sections,
10 it will be understood that each section will have a generally "C" shaped structure as shown in
11 Figure 14. In cases where a plurality of clamp sections are required, it will be understood
12 that the shape of the sections will vary. The sections 154 and 155 include radially extending,
13 longitudinal "connecting" flanges. Thus, for section 154, the connecting flanges are shown
14 at 156 and 158. For section 155, the connecting flanges are shown at 157 and 159. Each of
15 the connecting flanges 158 to 159 are provide with bolt holes, positioned so as to be aligned
16 when the clamp is in use. In such position, "clamping" bolts 160 and 162 are inserted
17 through the bolt holes of opposed connecting flanges of adjacent clamp sections. Nuts 161
18 and 163 are provided on the clamping bolts 160 and 162, respectively, so as to secure the
19 connecting flanges against each other. Thus, as shown in Figure 14, bolts 160, in
20 combination with nuts 161, serve to secure the connecting flanges 156 and 157 together.
21 Similarly, bolts 162 and nuts 163 serve to secure the connecting flanges 158 and 159
22 together. In this manner, the sections of the clamp 150 are joined together to form a
23 generally annular shaped structure forming a concentric ring over the outer circumference of
24 the pipe 12.

25 **[0094]** Once the sections forming the clamp 150 have been assembled as discussed
26 above, the clamp 150 is then secured to the outer surface of the pipe 12. In order to achieve
27 this, the clamp 150, once formed (by connecting the respective clamp sections) is provided
28 with two inner diameters, d1 and d2, both of which are larger than the outer diameter of the
29 pipe 12. As shown in Figure 13, the first inner diameter, d1, is larger than the second inner
30 diameter d2. When the clamp is in use, the section of the clamp having inner diameter d1 is
31 positioned proximal to the open end of the pipe 12. The opposite end of the clamp (i.e.
32 opposite the open end of the pipe 12) is provided with the inner diameter d2. The clamp
33 150 further includes a ramped surface 164 extending between the two diameters d1 and d2.
34 In a preferred embodiment, a shoe 166 is provided adjacent the ramped section 164. The

1 shoe 166 serves to extend the ramped surface 164. As will be understood by persons
2 skilled in the art upon reviewing the present description, in other embodiments of the
3 invention, the shoe 166 may be omitted or substituted with other similar functioning
4 elements. In this description, the shoe 166 is described as a unitary structure provided on
5 the clamp. However, it will be understood that the shoe 166 may be formed as separate
6 sections associated with or integral with each of the sections forming the clamp 150.

7 **[0095]** The clamp 150 is also provided with a gripper ring 170, which is formed by at
8 least two sections that are separated by spacing. For convenience, the gripper ring 170 will
9 be discussed further as a unitary element. As shown in Figure 13, the gripper ring 170 has a
10 generally annular ring shape preferably with a constant inner diameter capable of sliding
11 over the outer circumference surface of the pipe 12. The outer surface of the gripper ring
12 170 is provided with a ramped structure oppositely oriented to the ramped section 164 of the
13 clamp 150. As shown in Figure 13, this results in the gripper ring 170 having a varying outer
14 diameter, which is greater at the proximal end, proximal to the open end of the pipe 12, and
15 less at the distal end, opposite to the open end of the pipe 12. The outer surface of the
16 gripper ring is thereby provided with a ramped surface 171. As shown, the distal end of the
17 gripper ring 170 is adapted to be received under the ramped section 164 of the clamp and,
18 where present, under the shoe 166. When the clamp 150 is in position, the gripper ring 170
19 is positioned proximal thereto, thereby placing the gripper ring closer to the opening of the
20 pipe 12 (as shown in Figure 13). In this way, as the gripper ring 170 is advanced axially in
21 the distal direction over the pipe 12, i.e. away from the pipe opening and against the clamp
22 150, the gripper ring 170 is urged inwardly due to the interaction between the opposed
23 ramped sections 171 and 164. In the latter case, it will be understood that the ramped
24 surface 164 will be reflected in the structure of the shoe 166 and, where such shoe is
25 present, the inward deflection of the gripper ring 170 would be caused by interaction with
26 such shoe.

27 **[0096]** The clamp 150 further includes a radially extending, circumferential sealing flange
28 174. As shown in Figure 14, the sealing flange 174 is comprised of flange sections 175 and
29 176, provided, respectively, on clamp sections 155 and 154. For convenience, the flange
30 174 will be described as a unitary structure but will be understood to have such general
31 structure once the clamp 150 is assembled.

32 **[0097]** A plurality of "gripper" bolts 178 extend through openings 180 in the flange 174.
33 The gripper bolts 178 extend through the openings 180 in the proximal to distal direction (i.e.

1 along the axis of the pipe 12, when the clamp 150 is in the assembled state there-over),
2 wherein the bolt heads are proximal to the opening of the pipe 12. The terminal ends of the
3 gripper bolts 178 are adapted to bear against the proximal ends of the gripper ring 174.
4 Thus, in this arrangement, tightening of the bolts 178 forces the gripper ring 170 against the
5 inner surface of the clamp 150 and, therefore, under the ramped surface 164 thereof or the
6 shoe 166. In either case, the gripper ring 170, being of at least two sections, is deflected
7 inwardly and forced against the outer surface of the pipe 12. With sufficient force applied by
8 the tightening bolts, the gripper ring 170 is pressed tightly against the pipe surface to create
9 a strong clamping force. This is continued until a sufficient clamping force is achieved
10 wherein relative axial movement of between the clamp 150 and the pipe 12 is prevented.

11 **[0098]** In one aspect, the bolts 178 are received within cooperatively threaded openings
12 180. In other aspects, a nut and threaded rod arrangement can be used to achieve the
13 same purpose. In other aspects, the bolts 178 may be replaced with hydraulic rams or
14 magnetically driven rods etc. It will be appreciated that the invention is not limited to any
15 specific means of advancing the gripper ring 170. The bolts 178, and correspondingly
16 threaded openings 180, provide one such means. As shown in Figure 14, a plurality of bolts
17 178 are provided and are generally equally spaced circumferentially over the clamp. Such
18 an arrangement is preferred since it serves to advance the gripper ring 170 equally over the
19 circumference of the clamp 150.

20 **[0099]** The circumferential sealing flange 174 is also provided with a plurality of
21 generally circumferentially spaced bolt holes 182. Similarly, the sealing plate 152 is also
22 provided with corresponding bolt holes 184. When the apparatus of the invention is
23 positioned on the pipe 12, the sealing plate 152 is oriented so as to align bolt holes 184 with
24 bolt holes 182 provided on the flange 174. Once in this orientation, "sealing" bolts 186 are
25 inserted through bolt holes 184 and 182 and nuts 188 are used to urge sealing plate 174
26 towards the clamp 150. As discussed in reference to other embodiments of the invention,
27 the sealing plate 152 is preferably provided with a groove or race 190 having dimensions
28 sufficient to receive the open end of the pipe 12 therein. In order to form a secure seal
29 between the sealing plate 152 and the open end of the pipe 12, a sealing material 192 is
30 preferably provided within the groove 190. The sealing material may be an O-ring, a gasket
31 material or any other sealing material as described herein or as would be apparent to
32 persons skilled in the art.

1 **[00100]** In operation, the apparatus illustrated in Figures 13 and 14 are utilized as follows.
2 Firstly, as described above, the clamp 150 is assembled from the two or more pieces
3 (described above) over the outer surface of the pipe 12, adjacent to an opening thereof. The
4 sections of the gripper ring 170 are positioned adjacent the clamp 150. As noted in Figure
5 13, the sections of the gripper ring 170 are positioned so that the portion having the smaller
6 outer diameter is distally oriented, away from the opening and towards the clamp 150. Thus,
7 the gripper ring 170 is positioned so as to align its ramped section 171 in an opposite
8 manner as compared to the ramped section 164 of the clamp 150. Thus, the thinner portion
9 of the gripper ring 170 is positioned to be received within an annular space created by the
10 outer wall of the pipe 12 and the larger inner diameter portion of the clamp 150.

11 **[00101]** Once the clamp and gripper ring sections are assembled in the desired position
12 over the pipe 12, the clamp sections are secured together by means of clamping bolts 160,
13 162 and the associated nuts 161, 163, respectively. This results in the clamping sections
14 being urged together thereby also causing the gripper ring sections to be urged together.
15 The clamp sections may optionally be provided with spacers 181 such as that shown in
16 Figure 14. Such spacers serve to limit the amount of compression exerted by the clamp 150
17 over the gripper ring 170. In such manner, the desired clamping force on the clamp would
18 be controlled by the gripper bolts 178 as discussed further below.

19 **[00102]** Once the clamp 150 is assembled over the pipe 12 as discussed above, the
20 gripper bolts 178 are then tightened so as to force the gripper ring 170 towards the clamp
21 150 and against the ramped portion 164 or, where present, the shoe 166, which is provided
22 with an equally ramped surface. In the process, the gripper ring 170 is radially compressed
23 and thereby forced against the outer wall of the pipe 12. Further tightening of the bolts 178
24 creates a tight fit between the gripper ring 170 and the wall of the pipe 12, thereby
25 preventing relative axial movement between the clamp 150 and the pipe 12. Once the
26 clamp 150 is thus anchored to the wall of the pipe 12, the sealing plate 152 is positioned and
27 aligned with the circumferential flange 174 of the clamp 150. Tightening of the nuts 188 over
28 the sealing bolts 186 urges the sealing plate towards the clamp 150 (which is clamped on
29 the pipe 12) and, in the result, forces the sealing plate 152, and in particular the groove or
30 race 190 thereof, against the open end of the pipe 12. The nuts 188 are tightened until the
31 desired degree of sealing is achieved. With the sealing means 192 in place, a sealing
32 arrangement is achieved between the open end of the pipe 12 and the sealing plate 152. At
33 this point, the interior of the pipe 12 may be pressurized and subjected to pressure testing
34 for its integrity.

1 **[00103]** Figures 15 to 22 illustrate features of another embodiment of the invention. As
2 shown in Figure 15, the apparatus of the invention includes a clamp 200 that is adapted to
3 be secured to the outer wall of a pipe 12. The clamp includes a first, compression or
4 squeeze ring 202 and a second, or clamping ring 204. The first and second rings 202 and
5 204 are preferably unitary structures that are generally annular in shape. The rings 202 and
6 204 have respective internal and external diameters, with the internal diameters of each
7 being slightly larger than the outer diameter of the pipe 12 so as to allow the rings to be
8 slidably provided over the pipe. The clamp 200 further includes a generally annular gripper
9 ring 206, which also has an internal diameter and an external diameter. The internal
10 diameter of the gripper ring 206 is reducible, as described further below. However, in its
11 initial state, the internal diameter of the gripper ring 206 is greater than the external diameter
12 of the pipe 12 so as to allow the ring 206 to be slidably provided thereover. Gripper ring 206
13 is preferably formed of two or more sections. As shown in Figure 20, the gripper ring 206 is
14 formed, according to one embodiment of the invention, in two sections 206a and 206b. The
15 purpose of such multiple sections for the gripper ring 206 will become apparent in the
16 following description.

17 **[00104]** As shown in Figure 15, the clamp 200 is formed by first providing the
18 compression ring 202 over the outer surface of the pipe 12. This is achieved by sliding the
19 ring 202 over the pipe, adjacent an open end thereof. The gripper ring 206 is next
20 positioned adjacent the compression ring 202. As mentioned above, the gripper ring 206 is
21 preferably provided in two or more sections. Next the clamping ring 204 is positioned over
22 the pipe as shown in Figure 15. The compression ring 202 and clamping ring 204 are each
23 provided with a plurality of bolt holes, 208 and 210, respectively, as shown in Figures 16 and
24 18. In positioning the portions of the clamp 200 over the pipe, the bolt holes 208 and 210 of
25 the compression ring 202 and clamping ring 204 are aligned. Once in this position,
26 "clamping" bolts 212 are inserted into the aligned bolt holes and such bolts are tightened
27 with nuts 214. As will be understood in reviewing Figure 15, as the nuts 214 are tightened,
28 the clamping plate and compression plate are urged towards each other to produce the
29 required clamping force to secure the clamp 200 over the outer diameter of the pipe 12.

30 **[00105]** The compression ring 202 is preferably provided with a beveled inner diameter.
31 Thus, the internal diameter of the compression ring 202 is provided with a ramped surface
32 214 (as shown in Figures 15 and 17), such that a smaller inner diameter is provided distal to
33 the open end of the pipe 12 and a larger inner diameter is provided proximal to such open
34 end. The gripper ring 206 also comprises a generally annular shaped structure but having a

1 generally constant inner diameter, which faces the outer surface of the pipe 12 when the
2 apparatus is in use. The outer diameter of the gripper ring 206 includes a ramped surface
3 216 (as shown in Figures 15, 21 and 22). This results in the gripper ring 206 having a larger
4 outer diameter proximal to the opening of the pipe 12 and a smaller outer diameter distal to
5 the pipe opening. The clamping ring 204 is generally annular in shape and does not
6 necessarily include any beveled or ramped surfaces. However, the inner diameter of the
7 clamping ring 204 is smaller than the outer diameter of the gripper ring 206. This
8 arrangement of the compression ring, gripper ring and clamping ring is shown in Figure 15.

9 **[00106]** As shown, in assembling the apparatus over a pipe 12, the compression ring 202
10 is first slid over the pipe 12, followed by the gripper ring 206 and finally the clamping ring
11 204. It is noted that the thin, distal portion of the gripper ring 206 is adapted to be inserted
12 between the proximal end of the compression ring 202 and the outer wall of the pipe 12. As
13 the nuts 214 are tightened and the compression ring 202 is advanced against the clamping
14 ring 204, the gripper ring 206 is therefore urged against the outer wall of the pipe 12. The
15 proximal end of the gripper ring 206 is biased against the clamping ring 204 and, therefore,
16 prevented from axial movement with respect to the clamping ring. As explained above, the
17 gripper ring 206 is preferably provided in two or more sections, as illustrated in Figure 20.
18 Where the gripper ring 206 is provided in two sections, as shown in Figure 20, each of such
19 sections 206a and 206b have a generally arc shaped structure. The ends of each section,
20 206a and 206b, are preferably separated by space 207. The spaces 207 allow the sections
21 of the gripper ring 206 to be moved radially inwardly towards each other, thereby resulting in
22 a reduction of the inner diameter of the gripper ring 206. Thus, as the gripper ring 206 is
23 urged towards the wall of the pipe 12, the sections forming the gripper ring 206 are urged
24 together, thereby reducing the inner diameter of the annular gripper ring 206 and radially
25 compressing the gripper ring 206 over the outer wall of the pipe 12 to form a tight, clamping
26 engagement therewith. Thus, tightening of the nuts 214 results in the clamp 200 being
27 secured to the pipe wall so as to prevent relative axial movement there-between.

28 **[00107]** Returning to Figure 15, the apparatus of the invention is also provided with a
29 sealing plate 220, which functions generally in the same manner as described previously
30 with respect to other embodiments. In the embodiment of Figure 15, the sealing plate 220
31 includes a flange portion 222 having an outer diameter greater than that of the pipe 12 and
32 an inner diameter less than that of the pipe 12. The flange portion 222 is provided with a
33 groove or race 224 that is adapted to receive the open end of the pipe 12. The groove 224
34 includes a sealing member or membrane 226 that is capable of forming a seal between the

1 groove 224 and the open end of the pipe 12. The flange portion 222 includes a plurality of
2 bolt holes 228 for receiving "sealing" bolts 230. The sealing bolts 230 are adapted to extend
3 to the clamp 200 and be connected thereto. Nuts 232 are also provided, which cooperate
4 with the sealing bolts 230 to advance the sealing plate 220 towards the clamp 200. In the
5 result, the sealing plate is forced against the open end of the pipe 12 and the opening of the
6 pipe is sealed within the groove 224. Such sealing action is similar to that described above
7 with respect to other embodiments of the invention. In one embodiment, the bolts 230 may
8 be secured to the clamping ring 204 of the clamp. In another embodiment, as illustrated in
9 Figure 15, the sealing bolts 230 and clamping bolts 212 may comprise the same entity.
10 Thus, the single bolt serves to join the clamping and compression rings together as well as
11 to urge the sealing plate 220 towards the clamp 200. In such case, the bolts 217 are
12 elongated and capable of extending through the bolt holes 228 in the flange portion 222 of
13 the sealing plate 220. Thus, the two sets of nuts 214 and 232 would engage the same bolt
14 but would serve to provide, respectively, the required clamping force and sealing force. It
15 will be understood that the use of a single set of bolts may be advantageous in terms of
16 reducing the number of elements of the apparatus. However, the apparatus of the invention
17 will be understood to function equally with separate sealing and clamping bolts. In such
18 case, two sets of circumferentially spaced bolt holes will be provided on the clamping plate
19 204. One set will be used to receive the clamping bolts 212 and the other set will be used to
20 receive the sealing bolts 230.

21 **[00108]** The sealing plate 220 also includes a body portion 234 that is preferably integral
22 with the flange portion 222. The body portion 234 of the sealing plate 220 may comprise a
23 generally flat, plate-like structure as described previously. However, in the embodiment
24 shown in Figure 15, the body portion 234 has a convex shape, protruding beyond the
25 opening of the pipe 12. The body portion 234 may then be provided with a number of ports
26 236, to which may be connected pressurizing means (such as a hose to supply a
27 pressurizing fluid to the interior portion of the pipe 12), evacuation means (such as a hose to
28 drain the pressurized fluid from the pipe 12), pressure gauges, temperature gauges, relief
29 valves etc. Various other devices for connection to the ports 236 will be apparent to persons
30 skilled in the art.

31 **[00109]** Figure 23 illustrates a variation of the apparatus shown in Figure 15, and
32 illustrates another embodiment of the clamp, shown generally at 250. In Figure 23, the
33 sealing plate 220 is essentially the same as that discussed previously. Further, the clamping
34 ring 204 of the clamp 250 is also as described above. However, as shown, the clamp 250 of

Figure 23 is provided with a plurality of compression rings 202 and gripper rings 206. As will be understood, by providing a plurality of compression and gripper rings, 202 and 206, the amount of clamping force offered by the clamp 250 is increased. In the result, the clamp of Figure 23 is able to withstand higher pipe pressures than the clamp of Figure 15. The number of additional compression rings and clamping rings will vary based on the desired clamping force required and it will be understood that any number of such rings may be provided for any given clamp.

[00110] In order to ensure that each compression ring 202 acts upon a respective gripper ring 206, each of the compression rings 202 are separated by a separation ring 252. As will be understood, the separation rings 252 serve to prevent binding between each of the compression rings and to ensure that each of such compression rings act upon respective gripper rings 206. The separation rings 252 may comprise, for example, O-rings.

[00111] It will be understood that in situations where a given length of a pipe is to be tested, both ends of the pipe can be sealed using any of the sealing apparatus described above. In such case, the ends of the pipe will each be provided with the same or different ones of the apparatus of the invention. Each end of the pipe would thus be sealed and the interior of the pipe may then be pressurized for conducting an integrity test.

[00112] As described above, in some of the embodiments of the invention, the clamp includes a gripper ring (formed of two or more sections) that is provided with a ramped surface adapted to contact and cooperate with or engage an oppositely ramped surface on another portion of the clamp. In some cases, such oppositely ramped surface is provided on the clamp body or on a compression or "squeeze" ring as described above. It will be noted in the described embodiments that the gripper ring is positioned so that its thinner portion is oriented away from the pipe opening. As seen, for example in Figures 13 and 15, and as will be understood by persons skilled in the art, such an orientation would be preferred. Specifically, once the clamp is tightened against the exterior surface of the pipe, the clamp would be securely engaged and the sealing plate is then attached thereto so as to seal the open end of the pipe. Subsequently, when the interior of the pipe is pressurized (such as in cases where a pressure test is conducted on the pipe), it will be understood that such pressure will act to force the sealing plate of the apparatus away from the pipe opening in the axial direction. However, since the sealing plate is secured to the clamp by means of the sealing bolts (i.e. the bolts connecting the sealing plate to the clamp), the axial movement of the sealing plate would also exert an axial force on the clamp. In the result,

1 the clamp body or compression ring would be forced to travel over the gripper ring due to the
2 opposed ramped surfaces. As will be understood, such movement would cause the gripper
3 ring to be further compressed against the external surface of the pipe and, thereby, result in
4 strengthening the gripping force between the gripper ring and the exterior of the pipe. Thus,
5 even in the situation where a high pressure applies an axial force on the clamp, a
6 corresponding increase in clamping force results. The above mentioned orientation of the
7 gripper ring and the other clamp components comprises a preferred arrangement of the
8 apparatus of the invention, so as to allow increased clamping force upon application of an
9 axial force (such as due to pressurization of the pipe). However, it will be understood that
10 the orientation of the gripper ring and the clamp body or the compression ring may be
11 reversed while still providing an adequate clamping force on the pipe. For example, such
12 reversed orientation may be used in cases where the pipe is not pressurized or where the
13 required pressurization is minimal.

14 **[00113]** In the above description, reference is made to the use of bolts for securing
15 sections of the clamp together and for securing the sealing plate to the clamp. Such bolts
16 are described as extending through bolt holes provided in respective flanges. However,
17 although such arrangement is preferred, it will be appreciated that other means may be used
18 to achieve the desired purpose. For example, the respective flange may be urged together
19 using compression clamps etc. Magnetic means may also be used to urge the respective
20 elements towards each other. In addition, the above description has referred to the use of
21 threaded bolts having nuts provided on each end thereof. However, in another embodiment,
22 the bolts may include heads, whereby only a single nut is required to achieve the required
23 tightening. For this reason, the aforementioned bolts and equivalent elements that serve a
24 connection function (i.e. connecting two or more other elements together) may be referred to
25 generally as "connecting elements".

26 **[00114]** As illustrated in Figures 7 to 23 and as described above, the circumferential
27 clamp that is secured to the external surface of a pipe is preferably positioned distally of the
28 open end of the pipe by at least a short distance. As will be understood, such positioning
29 provides a degree of separation between the clamp and the sealing plate, thereby allowing
30 the sealing plate to be sufficiently sealed against the end of the pipe without being hindered
31 by the clamp itself. Furthermore, it will be understood that placing a circumferential clamp
32 close to an end of the pipe, and subjecting the pipe to a strong radially compressive force
33 may damage the end of the pipe and prevent it from being connectable to other pipes or to
34 other apparatus (such as vessels, flanges etc.). It will be understood that the above

described internal reinforcement (such as shown at 110 in Figure 10) may be used in combination with any of the external clamps described herein. In addition, having the ability to axially position the clamp at any location along the length of the pipe allows for a desired amount of clearance in the event that a weld is located near the open end of the pipe.

[00115] It will be understood that the external clamp and sealing plate of the invention can also be used on pipes that include a bend. For example, in a pipe comprising an elbow, the clamp may be positioned on one side of the bend with the sealing plate covering the pipe opening on an opposite side of the bend. In such case, the connecting elements between the clamp and the sealing plate may be adapted or oriented to provide the same sealing force as described above. For example, the clamp may be provided with an extension for cooperating with the connecting elements to engage the sealing plate. Various other such modifications to the invention are also possible.

[00116] It will be understood by persons skilled in the art that any number of, and types of embodiments of, the clamp of the invention can be used in combination. Such combined use would depend upon the specific use being contemplated and the specific combination will be apparent to persons skilled in the art. For example, the embodiment of Figure 11 may be combined with the embodiment of Figure 23 etc. In this example, the embodiment of Figure 23 can form a downstream “anchor” while the embodiment of Figure 11 is used upstream.

[00117] As discussed above, the apparatus of the invention is preferably used for sealing an end of a pipe so that the interior bore of the pipe can be pressurized such as for testing the integrity of the pipe. In one example, the integrity test is used for testing a weld that may be present on the pipe. Such a weld may serve to connect two pipe segments or to connect the pipe to another apparatus.

[00118] It will be understood that the above discussion has used geometric terms such as annular, disc, circumference, etc., for ease of reference. However, these terms should not be construed as limiting the invention to any specific shape of nozzle or pipe and various modifications of the apparatus will be apparent to persons skilled in the art to adapt same to any shape or design.

[00119] A further embodiment of the invention is illustrated in Figures 24 to 35. In this embodiment, the invention comprises combined internal and external clamps shown generally at 500. As shown in Figure 24, the combination clamp 500 includes an external

1 clamp 300, that is adapted to be secured to the outer surface of a pipe 12, and an internal
2 clamp 400, that is secured to the inner surface of the pipe 12. The external clamp 300
3 functions in a similar manner to the clamp 200 discussed above. For this reason, elements of
4 clamp 300 that are similar to previously described clamp 200 will be identified with similar
5 reference numerals but starting with "3". As shown, the external clamp 300 comprises a first
6 squeeze, or compression ring 302 and a second, clamping or sealing plate 304. As discussed
7 above, the compression ring 302 and clamping plate 304 are preferably each unitary in
8 structure. As discussed above, the compression ring 302 has an internal diameter and an
9 external diameter. The internal diameter of the compression ring 302 is preferably sized to be
10 slightly greater than the outer diameter of the pipe 12, whereby the compression ring 302 can
11 be slidably provided over the pipe 12. Unlike the previously described clamping plate 204, the
12 clamping plate 304 is designed to be positioned or abut against the open end of the pipe 12
13 and, therefore, sized so as to have a diameter, or at least a portion thereof, that exceeds the
14 diameter of the pipe 12. As shown in Figure 24, this arrangement serves to allow the clamping
15 plate 304 to cover the end face of the pipe 12 opening. The clamping plate 304 may be
16 provided with an internal diameter, as shown in Figures 24 - 26, so as to assume an annular
17 disc shape as shown in Figure 24. In other embodiments, such as where the pipe 12 has a
18 small diameter, the clamping plate 304 may simply comprise a solid plate. As also described
19 above with respect to other embodiments, the clamping plate 304 may be provided with a
20 groove or the like to receive the open end of the pipe 12. Such groove may similarly be
21 provided with a sealing member to form a seal with the end of the pipe 12 as described above.

22 **[00120]** The external clamp 300 also includes an external segmental gripper ring 306. As
23 described above, the external gripper ring 306 is generally annular in shape and has an inner
24 diameter that is sized to be provided over the outer circumference of the pipe 12, when the
25 gripper ring 306 is in its initial state. The inner diameter of the external gripper ring 306 is
26 reducible upon application of a suitable force, as discussed further below. Although the term
27 "ring" is used for external gripper ring 306, such ring is preferably formed of two or more
28 sections, which, when combined, form a ring over the pipe 12. It should also be noted that, as
29 discussed above, the sections forming the external gripper ring 306 are preferably spaced
30 apart so as to allow radial compression of its internal diameter, i.e. as the sections are brought
31 together over the pipe 12 surface.

- 1 **[00121]** As also discussed above, the compression ring 302 and external gripper ring 306
- 2 have oppositely directed ramped surfaces that cooperate to achieve the desired clamping

1 force on the outer surface of the pipe 12. As shown, compression ring 302 includes a ramped
2 surface 314 defined on the inner diameter thereof. As shown in Figure 24, the ramped surface
3 is arranged so as to provide the compression ring 302 with a slightly larger internal diameter
4 on the side of the ring 302 facing the opening of the pipe 12. Similarly, the external gripper
5 ring 306 is provided with a ramped surface 316 that is similar to that shown in Figures 20-22.
6 That is, the ramped surface 316 of the external gripper ring 306 is provided on the outer
7 diameter of the external gripper ring 306 and is arranged oppositely to the ramped surface 314
8 of the compression ring 302. When the clamp 300 is in use, the gripper ring 306 is arranged
9 so as to allow a portion of the ramped surface 316 to engage the ramped surface 314 of the
10 compression ring 302, with the ramped surfaces 316 and 314 being oppositely directed as
11 shown in Figure 24.

12 **[00122]** The external clamp 300 includes a number of clamping bolts 312 and cooperating
13 nuts 314, which serve the same purpose as described above. Specifically, the nuts 314 and
14 bolts 312 combine to urge the compression ring 302 and clamping plate 304 together, thereby
15 causing the compression ring 302 to bear against the sections of the external gripper ring 306,
16 thereby compressing the latter against the outer surface of the pipe. As shown in Figure 26,
17 the clamping plate 304 is provided with a plurality of boltholes 310 through which the bolts 312
18 are passed. Similarly, as shown in Figure 28, the compression ring 302 is also provided with a
19 plurality of boltholes 308 through which the bolts 312 are passed.

20 **[00123]** Figure 24 also illustrates an internal clamp 400 that also forms part of the
21 apparatus of this embodiment. As will be understood by persons skilled in the art, the internal
22 clamp 400 operates in a similar manner to the external clamp 300 just described. As shown,
23 the internal clamp 400 includes a backplate 401 that has an outer diameter that is sized to
24 allow the backplate 401 to be inserted into the pipe 12. An internal compression ring 402 is
25 also provided adjacent to the backplate 401, when the apparatus is in use. As shown, the
26 internal compression ring 402 is also sized to be inserted within the pipe 12. A resilient
27 deformable sealing member, such as an O-ring 403 is provided between the backplate 401
28 and internal compression ring 402. The purpose of the seal 403 will become apparent in the
29 following description.

30 **[00124]** The internal compression ring 402 is preferably annularly shaped so as to result in
31 an inner and outer diameter. As mentioned above, the outer diameter of the internal
32 compression ring 402 is sized so as to be provided within the pipe 12. The outer diameter of

1 the internal compression ring 402 is provided with a ramped surface 414, as shown in
2 Figures 24 and 30. The ramped surface 414 serves to provide the internal compression ring
3 402 with a slightly smaller outer diameter on the side facing the opening of the pipe 12.

4 **[00125]** The internal clamp 400 also includes an internal gripper ring 406 that is also
5 provided preferably in two or more sections, such as sections 406a and 406b shown in
6 Figures 33 and 34. The actual number of sections will depend on the diameter of the ring
7 406. The internal gripper ring 416 comprises a generally flat outer diameter surface, while
8 the inner diameter is provided with a ramped surface 416, that is designed to cooperate with
9 the ramped surface 414 of the internal compression ring 402. As shown in Figure 24, the
10 ramped surfaces 414 and 416 are oppositely oriented, whereby the ramped surface 416 of
11 the internal gripper ring 406 is adapted to slide over the ramped surface 414 of the internal
12 compression ring 402, upon urging of the clamp sections together, thereby causing the
13 internal gripper ring 406 to bear against the inner surface of the pipe 12.

14 **[00126]** The inner compression ring 402 is provided with a plurality of boltholes 408 as
15 shown in Figure 39. A similar set of boltholes 409 is provided on clamping plate 304, as
16 shown in Figure 26. A plurality of bolts 412 are provided through the boltholes 408 and 409
17 and, in one embodiment of the invention, extend into cooperatively threaded openings 411
18 provided on the backplate 401. Thus, when the internal clamp is in use, the backplate 401 is
19 first inserted into the pipe 12 followed by the sealing member 403, the internal compression
20 ring 402 and then the internal gripper ring 406. The bolts 412 are then inserted through the
21 boltholes 408 and 409 and the ends of such bolts 412 are threaded into the openings 411.
22 Once the bolts 412 are tightened into the openings 411, nuts 414 are provided on the bolts
23 412, which are tightened to pull together the various elements of the internal clamp 400.
24 Thus, as will be understood, as the internal clamp 400 is tightened, the resilient member 403
25 is pressed between the backplate 401 and internal compression ring 402, whereby the
26 resilient member is urged against the inner surface of the pipe 12, thereby forming a seal
27 therewith. To facilitate the formation of the seal, one or both of the backplate 401 or internal
28 compression ring 402 may be provided with a beveled edge for directing the sealing member
29 403 radially outwardly to form the seal with the inner surface of the pipe 12.

30 **[00127]** In the above description, the backplate 401 is described as having threaded
31 openings 411 for receiving the bolts 412. However, it will be understood that variations of
32 this connecting means may be employed in the invention without affecting its method of
33 operation. For example, the bolts 412 may be fixedly attached to the backplate 401.

1 Alternatively, the bolts 412 may extend through the backplate 401 and secured thereto with
2 nuts (not shown). In the latter case, it will also be understood that the bolts 412 would need to
3 be secured to the backplate 401 prior to insertion into the pipe 12.

4 **[00128]** Simultaneously with forming the aforementioned seal, the internal gripper ring 406
5 is urged outwardly due to the advancing internal compression plate and the cooperating
6 ramped surfaces 414 and 416. In the result, the sections forming the internal gripper ring 406
7 are pressed against the inner surface of the pipe 12 to form a clamping force therewith. As
8 shown in Figure 35, the internal gripper ring 406 may be provided with a textured or serrated
9 outer diameter surface 413, in order to enhance the frictional engagement of the internal
10 gripper ring 406 against the inner surface of the pipe 12.

11 **[00129]** In operation, it will be apparent to persons skilled in the art that the external clamp
12 300 may be provided on a pipe first, followed by engagement of the internal clamp 400. With
13 the two clamps 300 and 400 in place, it will be understood that the wall of the pipe 12 is
14 essentially “pinched” from outside and inside, whereby the securing of the combined external
15 and internal clamp is enhanced.

16 **[00130]** Once the combination clamp 500, comprising the external 300 and internal clamp
17 400, is in place, the interior of the pipe may be pressurized as described above. As described,
18 the combination clamp 500 also serves to seal the end of the pipe 12. To assist in the
19 pressurization, the backplate 401 may be provided with one or more pipes 420 through which
20 the interior of the pipe 12 may be filled with the required pressurizing fluid. The backplate 401
21 is preferably provided with an aperture 422 to receive the pipe 420. It will be understood that
22 various gauges, monitors etc. may also be used with the combination clamp 500.

23 **[00131]** Although the invention has been described with reference to certain specific
24 embodiments, various modifications thereof will be apparent to those skilled in the art without
25 departing from the purpose and scope of the invention as outlined in the claims appended
26 hereto. Any examples provided herein are included solely for the purpose of illustrating the
27 invention and are not intended to limit the invention in any way. Any drawings provided herein
28 are solely for the purpose of illustrating various aspects of the invention and are not intended
29 to be drawn to scale or to limit the invention in any way. The disclosures of all prior art recited
30 herein are incorporated herein by reference in their entirety.

CLAIMS

1. An apparatus for closing and sealing the bore of an open end of a pipe, comprising:
- 5 a) a front plate for abutting the end face of the pipe end;
- b) an outer clamping means for frictionally and circumferentially engaging the external surface of the pipe end, said means comprising a segmental outer gripper ring positionable on the external surface and an outer compression ring mountable on the gripper ring, said rings having cooperating contacting ramped surfaces;
- 10 c) means for connecting and urging the front plate and compression ring together so that the compression ring compresses the gripper ring against the pipe end's external surface;
- d) an inner clamping means for frictionally and circumferentially engaging the internal surface of the pipe end, said inner clamping means comprising a segmental
- 15 inner gripper ring positionable against the internal surface and an inner compression ring mountable within the inner gripper ring, said inner rings having cooperating contacting ramped surfaces;
- e) a movable back plate for transversely positioning within the bore of the pipe end adjacent the inner end of the inner clamping means;
- 20 f) an annular deformable resilient seal means for positioning between the back plate and the inner compression ring; and
- g) means for connecting and urging the back plate and inner compression ring together so that they may compress and deform the seal means into sealing engagement with the pipe end's internal surface and so that the inner compression ring
- 25 may also compress the inner gripper ring against the internal surface;
- h) means, connecting the backplate with the front plate, for urging the backplate toward the front plate when in use;
- i) whereby the back plate, seal means, inner clamping means and front plate may combine to close and seal the pipe bore when tightened together.
- 30
2. The apparatus as set forth in claim 1 wherein:
the means c) and g) each comprises threaded nut and bolt assemblies.

3. The apparatus as set forth in claim 2 comprising:
means for introducing pressurized liquid into the bore of the pipe through the front and back plates.

5

4. The apparatus as set forth in claim 1 wherein each gripper ring has a textured inner surface for engaging the pipe.